

APPENDIX A

SAFETY APPROVED SUPPRESSIVE SHIELDS

A.1 INTRODUCTION

This appendix describes the safety approved suppressive shield designs in some detail and provides guidance concerning acceptable modifications. Brief information is provided in Tables A-1 through A-8 concerning each design group's physical size, weight, construction, and cost. Charge weights used for design and to proof test each shield group are listed in the tables for various types of explosives. The explosive quantities are also shown in terms of their TNT equivalent. The calculated values for reflected impulse, reflected pressure, and quasi-static pressure were obtained from Chapter 3 using the TNT equivalent weight. Measured values are included in the tables where data were available. Most of the information contained in Tables A-3 through A-6 and Table A-8 has been extracted from safety approval documentation (Ref. A-1). Additional information on the approved safety shield designs is presented in the following paragraphs of this appendix.

In general, the methods used for designing suppressive shields have always been conservative. However, some of the suppressive shields were designed and proof tested early in the development of suppressive shielding technology and may be over-designed. The methods of analysis presented in this handbook are current design techniques which were not used in the earlier design developments. Some of the earliest designs were the Shield Groups 4, 5 and the Prototype 81-mm Shield. Later designs which used the methods of analysis presented in this handbook include Shield Groups 3, 6 and Milan 81-mm Suppressive Shield.

Copies of the fabrication drawings for each approved shield

Table A-1

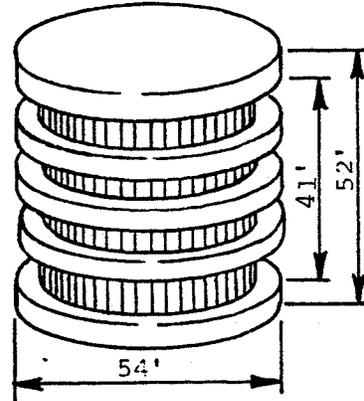
SUPPRESSIVE SHIELD GROUP 1

Inside dimensions: 46 ft diameter,
41 ft high

Weight: 5,760,000 lb

Type construction: Interlocked I-beam
walls with steel
liner and reinforced
concrete base and top.

Unit cost: 84,144 man-hours, ap-
proximately \$1,100,000
(est) (1975 costs)



Charge weight (Comp B):

- a. Design 2,500 lb (2870 lb TNT equiv.)
- b. Proof (25% overcharge) 3,125 lb (3588 lb TNT equiv.)

Reflected impulse (sidewall):

	<u>Calculated</u>	<u>Measured</u>
a. Design	1364 psi-ms	N/A
b. Proof	1647 psi-ms	Not tested

Reflected pressure (sidewall):

	<u>Calculated</u>	<u>Measured</u>
a. Design	2800 psi	N/A
b. Proof	3200 psi	Not tested

Quasi-static pressure:

	<u>Calculated</u>	<u>Measured</u>
a. Design	160 psi	N/A
b. Proof	185 psi	Not tested

Blowdown time (design): 58 msec with $\alpha_e = 5.0\%$ (total w/o liner)
600 msec with $\alpha_e = 0.4\%$ (total w/ liners)

Nominal wall thickness (fragment stopping): 4 inches steel

Status: Preliminary design concept complete; not safety approved;
testing may be required for approval.

Table A-2

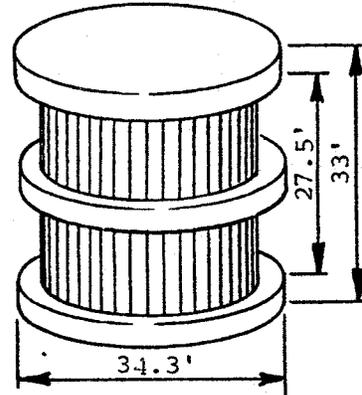
SUPPRESSIVE SHIELD GROUP 2

Inside dimensions: 31 ft diameter,
27.5 ft high

Weight: 1,581,840 lb

Type construction: Interlocked I-beam
walls with steel
liner and reinforced
concrete base and top.

Unit cost: 32,496 man-hours, ap-
proximately \$475,000
(est) (1975 costs)



Charge weight (Comp B):

- a. Design 750 lb (861 lb TNT equiv.)
- b. Proof (25% overcharge) 937.5 lb (1076 lb TNT equiv.)

Reflected impulse (sidewall):

	<u>Calculated</u>	<u>Measured</u>
a. Design	913 psi-ms	N/A
b. Proof	1102 psi-ms	Not tested

Reflected pressure (sidewall):

	<u>Calculated</u>	<u>Measured</u>
a. Design	2800 psi	N/A
b. Proof	3200 psi	Not tested

Quasi-static pressure:

	<u>Calculated</u>	<u>Measured</u>
a. Design	160 psi	N/A
b. Proof	185 psi	Not tested

Blowdown time (design): 58 msec with $\alpha_e = 5.0\%$ (total w/o liner)
600 msec with $\alpha_e = 0.4\%$ (total w/ liners)

Nominal wall thickness (fragment stopping): 2.7 inches steel

Status: Preliminary design concept complete; not safety approved; testing may be required for approval.

Table A-3

SUPPRESSIVE SHIELD GROUP 3

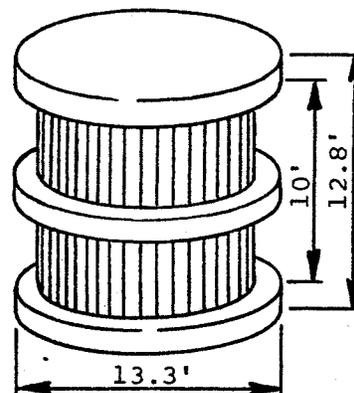
Note: Shield Group 3 is a one-quarter geometrical scale model of Shield Group 1.

Inside dimensions: 11.25 ft diameter, 10 ft high

Weight: 90,000 lb

Type construction: Interlocked I-beam walls with steel liner and reinforced concrete base and top.

Unit cost: 5,259 man-hours, approximately \$75,000 (1975 costs)



Charge weight (50-50 pentolite):

- a. Design 36.6 lb (41.32 lb TNT equiv.)
- b. Proof (25% overcharge) 45.7 lb (51.6 lb TNT equiv.)

Reflected impulse (sidewall):

	<u>Calculated</u>	<u>Measured</u>
a. Design	333 psi-ms	N/A
b. Proof	402 psi-ms	435 psi-ms

Reflected pressure (sidewall):

	<u>Calculated</u>	<u>Measured</u>
a. Design	2800 psi	N/A
b. Proof	3200 psi	2386 psi

Quasi-static pressure:

	<u>Calculated</u>	<u>Measured</u>
a. Design	160 psi	N/A
b. Proof	185 psi	187 psi

Blowdown time (design): 52 msec with $\alpha_e = 5.0\%$ (total w/o liner)
 600 msec with $\alpha_e = 0.4\%$ (total w/ liners)
 Nominal wall thickness (fragment stopping): 1 inch steel

Status: Safety approved

Table A-4

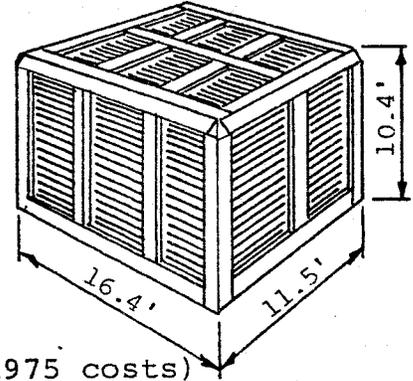
SUPPRESSIVE SHIELD GROUP 4

Inside dimensions*: 9.2 ft wide
 x 13.1 ft long
 x 9.3 ft high

Weight: 79,159 lb

Type construction: I-beam frame with
 panels of nested angles
 and perforated plates.

Unit cost: 6,500 man-hours, ap-
 proximately \$105,000 (1975 costs)



Charge Weight (50/50 Pentolite):

- a. Design 9 lb (10.16 lb TNT equiv.)
- b. Proof (25% overcharge) 11.25 lb (12.7 lb TNT equiv.)

Reflected impulse (sidewall):

	<u>Calculated</u>	<u>Measured</u>
a. Design	147 psi-ms	N/A
b. Proof	170 psi-ms	-

Reflected pressure (sidewall):

	<u>Calculated</u>	<u>Measured</u>
a. Design	1150 psi	N/A
b. Proof	1480 psi	1143 psi

Quasi-static pressure:

	<u>Calculated</u>	<u>Measured</u>
a. Design	62 psi	N/A
b. Proof	70 psi	44 psi

Blowdown time (design): 51 ms with $\alpha_e = 3.0\%$ (total)

Nominal wall thickness (fragment stopping): 1.46 inches steel

Status: Safety approved

* Dimensions given are for equipment clearance; dimensions for pressure calculations are 9.48'H x 9.66'W x 14.56'L.

Table A-5

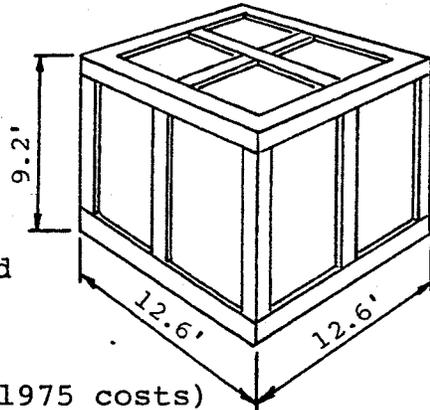
SUPPRESSIVE SHIELD GROUP 5

Inside dimensions: 10.4 ft wide
 x 10.4 ft long
 x 8.5 ft high

Weight: 16,772 lb

Type construction: Steel frame with panels of angles, perforated plates and screens.

Unit Cost: 3,174 man-hours, approximately \$55,000 (1975 costs)



Charge weight (C-4):

- a. Design 1.84 lb (1.98 lb TNT equiv.)
- b. Proof (25% overcharge) 2.44 lb (2.63 lb TNT equiv.)

Reflected impulse (sidewall):

	<u>Calculated</u>	<u>Measured</u>
a. Design	46.5 psi-ms	N/A
b. Proof	56.6 psi-ms	68 psi-ms

Reflected pressure (sidewall):

	<u>Calculated</u>	<u>Measured</u>
a. Design	150 psi	N/A
b. Proof	192 psi	346 psi

Quasi-static pressure:

	<u>Calculated</u>	<u>Measured</u>
a. Design	26 psi	N/A
b. Proof	32 psi	33 psi

Blowdown time (design): 5 ms with $\alpha_e = 15.5\%$ (panels)

Nominal wall thickness (fragment stopping): 0.427 inch steel

Status: Safety approved

Table A-6a

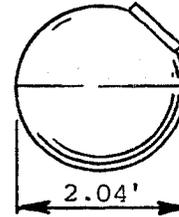
SUPPRESSIVE SHIELD GROUP 6A

Inside dimensions: 2 ft diameter

Weight: 165 lb

Type construction: Mild steel sphere
(no venting)

Unit cost: 130 man-hours, approximately \$2,500 (1975 costs)



Charge weight (50-50 pentolite):

- a. Design 13.63 oz (0.962 lb TNT equiv.)*
- b. Proof (25% overcharge) 17.04 oz (1.202 lb TNT equiv.)

Reflected impulse:

	<u>Calculated</u>	<u>Measured</u>
a. Design	195 psi-ms	N/A
b. Proof	234 psi-ms	-

Reflected pressure:

	<u>Calculated</u>	<u>Measured</u>
a. Design	6900 psi	N/A
b. Proof	7800 psi	-

Quasi-static pressure:

	<u>Calculated</u>	<u>Measured</u>
a. Design	480 psi	N/A
b. Proof	570 psi	600 psi

Blowdown time (design): N/A

Nominal wall thickness (fragment stopping): 0.25 inch steel

Status: Safety approved

* The design charge can be a single charge or multiple charges which do not exceed the total specified charge weight. See paragraph A.5.2.a for multiple charge criteria.

Table A-6b (concluded)

SUPPRESSIVE SHIELD GROUP 6B

Inside dimensions: 2 ft diameter
 Weight: 165 lb
 Type construction: Stainless steel sphere
 (no venting)
 Unit cost: 130 man-hours, approxi-
 mately \$2,500 (1975 costs)



Charge weight (C-4):

- a. Design 8.23 oz (0.5545 lb TNT equiv.)*
- b. Proof (25% overcharge) 10.29 oz (0.693 lb TNT equiv.)

Reflected impulse:

	<u>Calculated</u>	<u>Measured</u>
a. Design	119 psi-ms	N/A
b. Proof	144 psi-ms	-

Reflected pressure:

	<u>Calculated</u>	<u>Measured</u>
a. Design	4900 psi	N/A
b. Proof	5700 psi	-

Quasi-static pressure:

	<u>Calculated</u>	<u>Measured</u>
a. Design	330 psi	N/A
b. Proof	390 psi	-

Blowdown time (design): N/A

Nominal wall thickness (fragment stopping): 0.25 inch steel

Status: Safety approved

* The design charge can be a single charge or multiple charges which do not exceed the total specified charge weight. See paragraph A.5.2.b for multiple charge criteria.

Table A-7

SUPPRESSIVE SHIELD GROUP 7

Final design criteria have not been established for the Group 7 shield, and its further development is currently unfunded.

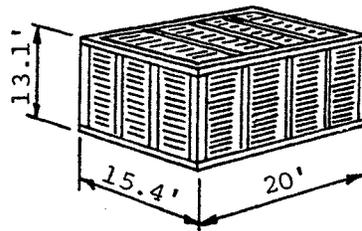
Table A-8a

PROTOTYPE 81-mm SHIELD

Inside dimensions: 14 ft wide
 x 18.7 ft long
 x 12.4 ft high

Weight: 50,000 lb

Type construction: Box-beam frame with panels of Z-shapes and perforated plates.



Unit cost: 4,095 man-hours, approximately \$80,000 (1975 costs)

Design charge weight:

- a. 6.72 lb C-4 (7.24 lb TNT equiv.) for incident and reflected overpressure and impulse.
- b. 10.1 lb C-4 (10.9 lb TNT equiv.) for quasi-static pressure; $W/V = 0.0034 \text{ lb/ft}^3$ (for TNT equiv.)
- c. 4 ea. M374, 81-mm mortar projectiles

Reflected pressure (sidewall):

	<u>Calculated</u>	<u>Measured</u>
a. Design	220 psi	N/A
b. Proof	260 psi	-

Quasi-static pressure:

	<u>Calculated</u>	<u>Measured</u>
a. Design	36 psi	N/A
b. Proof	42 psi	-

Blowdown time (design): 85 ms with $\alpha_e = 4.3\%$ (total)

Nominal wall thickness (fragment stopping): 1.23 inches steel

Status: Safety approved

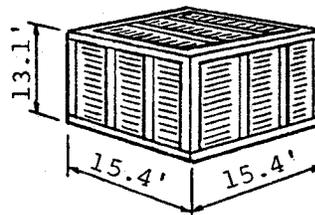
Table A-8b (concluded)

MILAN 81-mm SUPPRESSIVE SHIELD

Inside dimensions: 14 ft wide
 x 14 ft long
 x 12.4 ft high

Weight: 40,625 lb

Type construction: Box-beam frame with panels of Z-shapes and perforated plates.



Unit cost: To be determined

Design charge weight:

- a. 4.2 lb C-4 (4.53 lb TNT equiv.) for incident and reflected overpressure and impulse.
- b. 6.3 lb C-4 (6.79 lb TNT equiv.) for quasi-static pressure; $W/V = 0.0028 \text{ lb/ft}^3$ (for TNT equiv.)
- c. 3 ea M374, 81-mm mortar projectiles

Reflected pressure (sidewall):

	<u>Calculated</u>	<u>Measured</u>
a. Design	150 psi	N/A
b. Proof	180 psi	N/A

Quasi-static pressure:

	<u>Calculated</u>	<u>Measured</u>
a. Design	32 psi	N/A
b. Proof	37 psi	N/A

Blowdown time (design): 78 ms with $\alpha_e = 4.3\%$ (total)

Nominal wall thickness (fragment stopping): 1.23 inches steel

Status: Safety approved

design are included in this appendix. Authorized agencies may obtain full-size copies of the drawings from the U.S. Army Engineer Division, Huntsville, HNDED-CS, P. O. Box 1600, West Station, Huntsville, Alabama 35807.

A.2 SHIELD GROUP 3

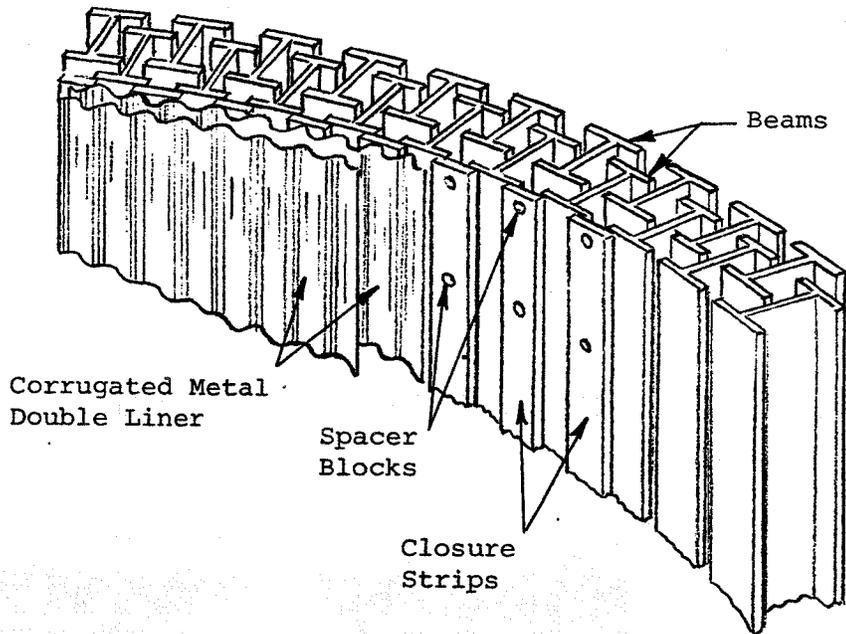
A.2.1 Description

The Group 3 suppressive shield is of cylindrical configuration with walls of interlocked I-beams and a reinforced concrete roof and foundation as illustrated in Fig. A-1. The inside dimensions are 11.25-foot diameter and 10 feet high; the outside dimensions are 13.3-foot diameter and 12.8 feet high.

The sidewalls of the cylinder are assembled by using S3 x 5.7 beams interlocked as illustrated in Fig. A-1. Reinforced concrete slabs attach to and support the upper and lower ends of the vertical beams. In addition to the support provided the beams by the roof and foundation, there is an intermediate steel hoop encircling the middle of the cylinder. The hoop is fabricated from 10 layers of 5-inch wide by 1/2-inch thick steel plates. Joints in each 1/2-inch plate of a hoop are welded together to ensure continuity around the hoop. The construction details are shown in Fig. A-2.

Access to the interior of the shield is provided by double-leaf doors swinging inward. The door leaves shown in Fig. A-3 are curved to match the contour of the shield walls and fabricated using deeper beam sections than those of the walls; see Fig. A-2c. Top and bottom plates of 1/2-inch steel maintain the individual beams in their relative positions. Edges of the opening for the door are reinforced with square steel tubing which also serves as a hinge support for each door half. When the doors are closed, the upper edge is restrained from blowing outward by the band circling the middle of the shield. The lower edge butts against a restraint constructed from a piece of

BRL-TEST 198



Wall Cross Section Detail

Figure A-1. Group 3 Suppressive Shield

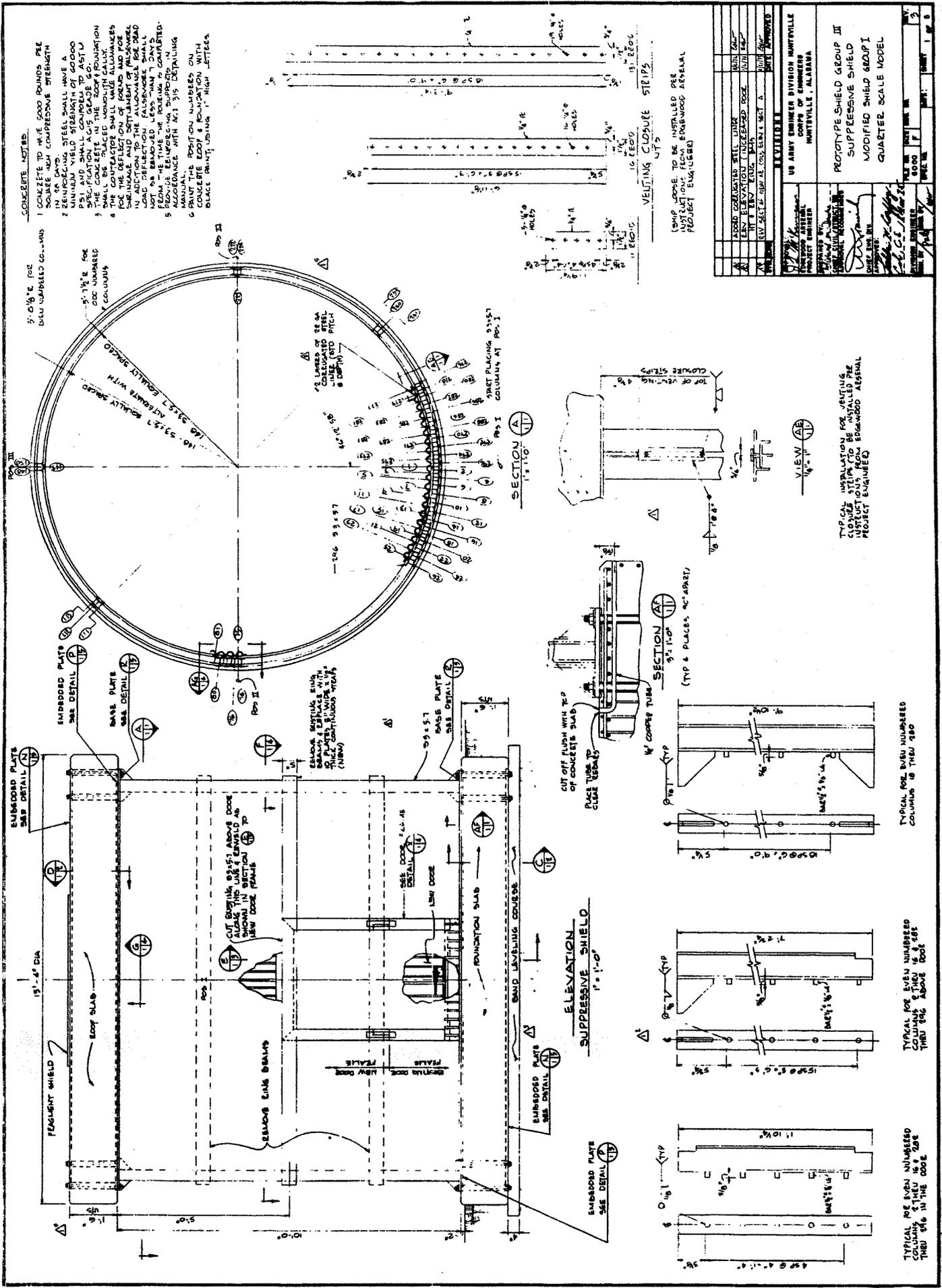
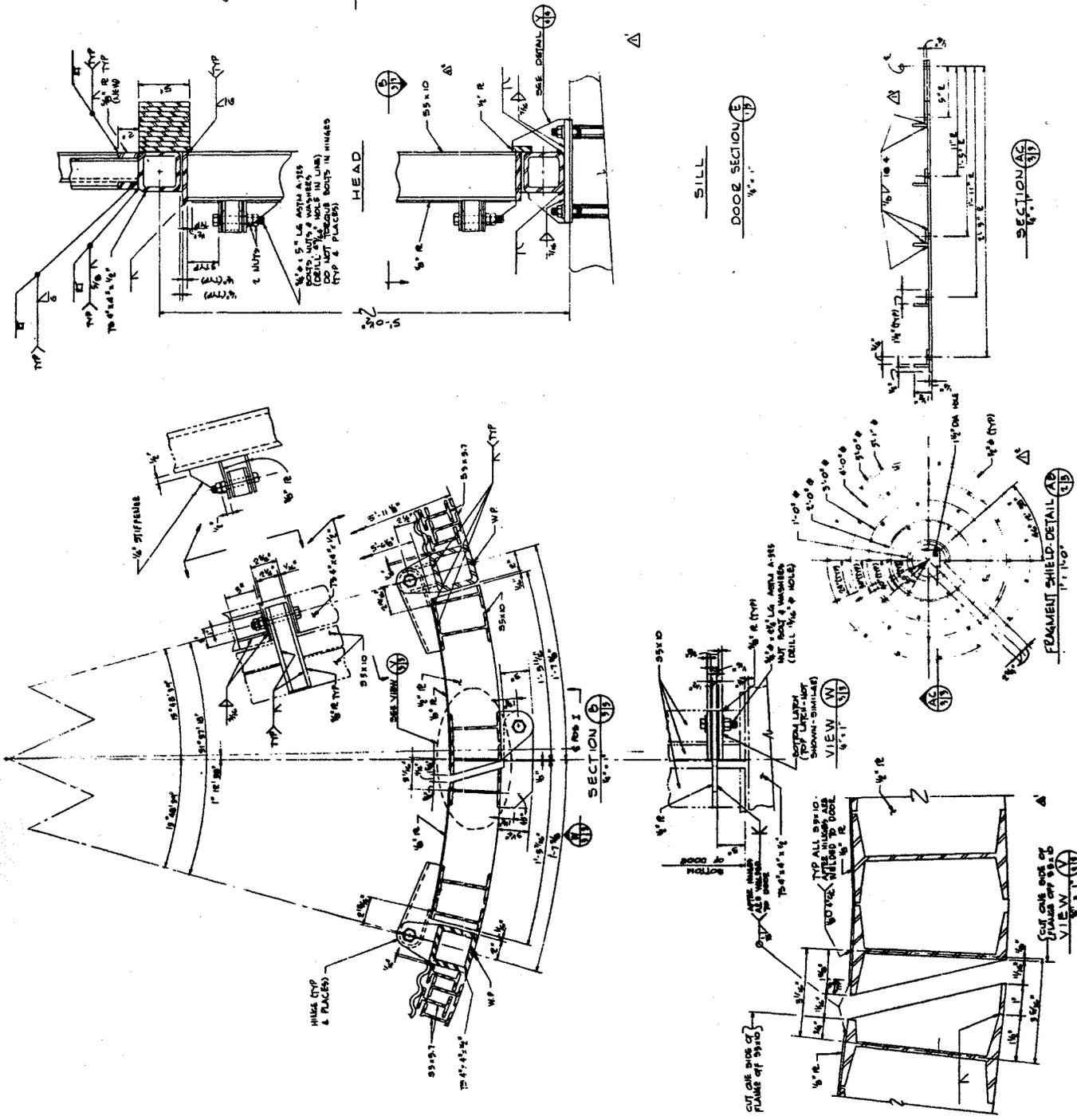


Figure A-2a. Group 3 Shield Construction Details

- STRUCTURAL STEEL NOTES**
1. FABRICATION AND SECTION SHALL CONFORM TO AISC SPECIFICATIONS.
 2. ALL SHAPES PLATES AND BARS SHALL CONFORM TO ASTM A 36 UNLESS NOTED OTHERWISE.
 3. ALL STRUCTURAL STEEL TUBING SHALL CONFORM TO ASTM A 500.
 4. ALL BOLTS, NUTS AND WASHERS SHALL BE $\frac{1}{2}$ " & UP.
 5. ALL $\frac{1}{2}$ " & UP SHALL BE GALVANNEAL AND NOT MADE OF UNSWEETENED STEEL.
 6. ALL WELDS SHALL BE PERFORMED BY FLAME CUTTING AND SHALL BE REWORKED DURING CONSTRUCTION TO CORRECT MISALIGNMENT OF JOINTS AND FOUNDATION SLABS.
 7. WELDING SHALL CONFORM TO AMERICAN WELDING SOCIETY STRUCTURAL WELDING CODE AWS D1.1 UNLESS NOTED OTHERWISE.
 8. ALL BOLT NUTS TO BE $\frac{1}{2}$ " PULL PENETRATION UNLESS NOTED OTHERWISE.
 9. TORQUE BOLTS TO 170 FT-LBS.
 10. HONGS IN BASE PLATES AT EACH END OF 35.5" TUBING SHALL BE DRILLED USING A TEMPLATE CENTER MATCHED DRILLED.
 11. $\sqrt{\text{E}}$ RADIOGRAPHIC TESTING OF WELDS REQUIRED WHERE SYMBOL IS SHOWN ON DRAWINGS.

- PAINTING NOTES**
1. ALL METAL SURFACES SHALL BE PRIME AND PAINTED EXCEPT THREADS OF BOLTS AND NUTS.
 2. ALL SURFACES TO HAVE ONE COAT OF PRIMER APPLIED BEFORE ASSEMBLED INTO CAGE SECTION.
 3. ALL SURFACES TO HAVE ONE COAT OF PRIMER APPLIED TO PREVENT PRIMING OF THOSE AREAS.
 4. AFTER CAGE HAS BEEN COMPLETELY ASSEMBLED, ALL WELDS AND UNPAINTED SURFACES SHALL BE PAINTED WITH ONE COAT OF PRIMER.
 5. AFTER ASSEMBLY, THE CAGE SECTION SHALL BE PAINTED WHITE ON ALL VISIBLE INTERIOR & EXTERIOR SURFACES.
 6. INSTRUCTIONS FOR ADDITIONAL INFORMATION ON PAINTING SHALL BE OBTAINED FROM THE PROJECT ENGINEER.
 7. ALL WHITE PAINT HAS BEEN APPLIED. PRINT THE POSITION NUMBERS ON CAGE SECTION WITH BLACK PAINT USING 1" HIGH LETTERS.



DESIGNED BY	DATE	SCALE	NO.
PROJECT ENGINEER	DATE	SCALE	NO.
CHECKED BY	DATE	SCALE	NO.
APPROVED BY	DATE	SCALE	NO.
US ARMY ENGINEER DIVISION, HARTSVILLE, ALABAMA			
PROTOTYPE SHIELD GROUP III			
SUPPLEMENTARY SHIELD			
MODIFIED SHIELD GROUP I			
QUARTER SCALE MODEL			
DATE	SCALE	NO.	REV.
1954	1/4\"/>		

Figure A-2c. Group 3 Shield Construction Details (continued)

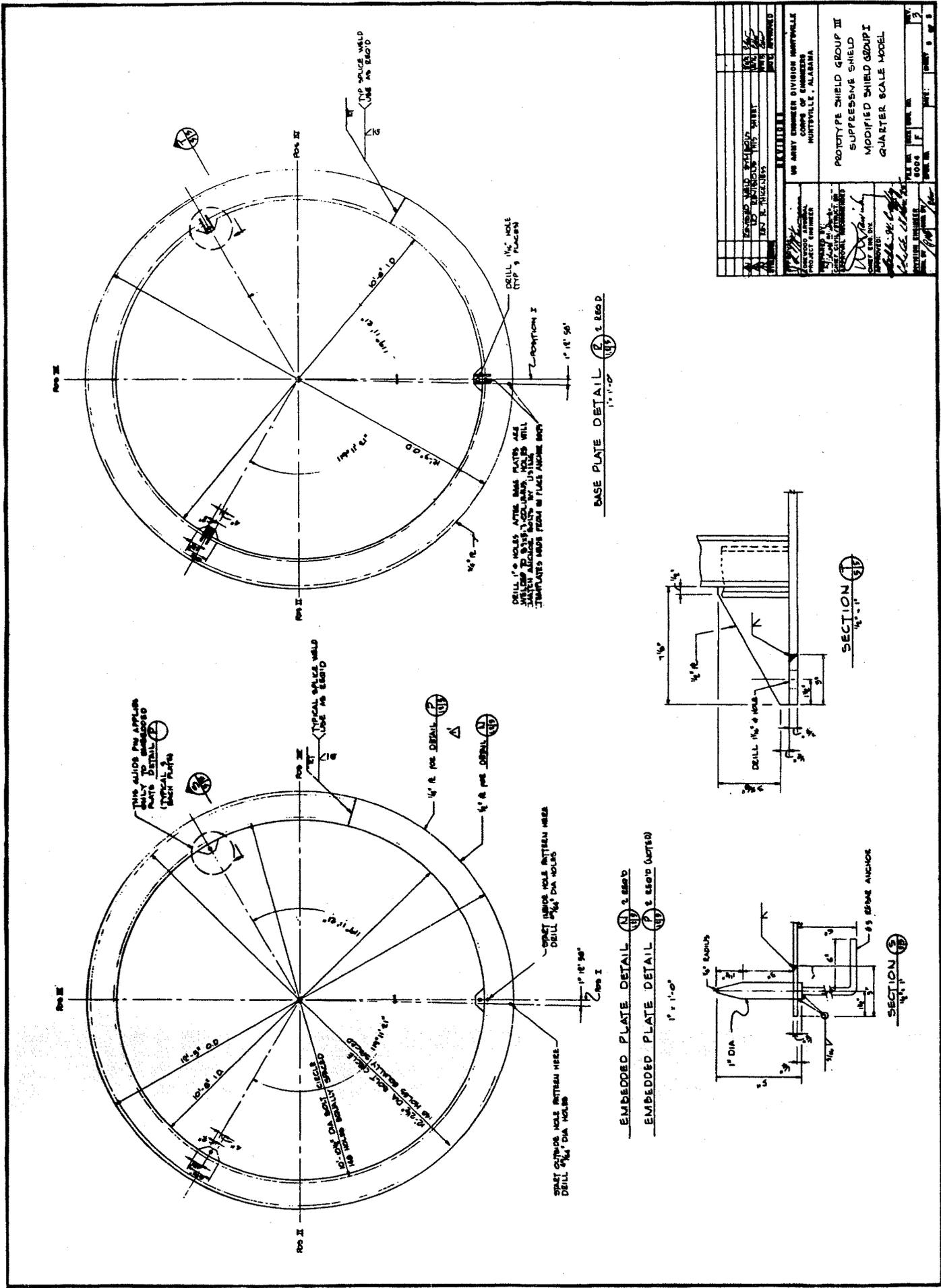


Figure A-2e. Group 3 Shield Construction Details (concluded)

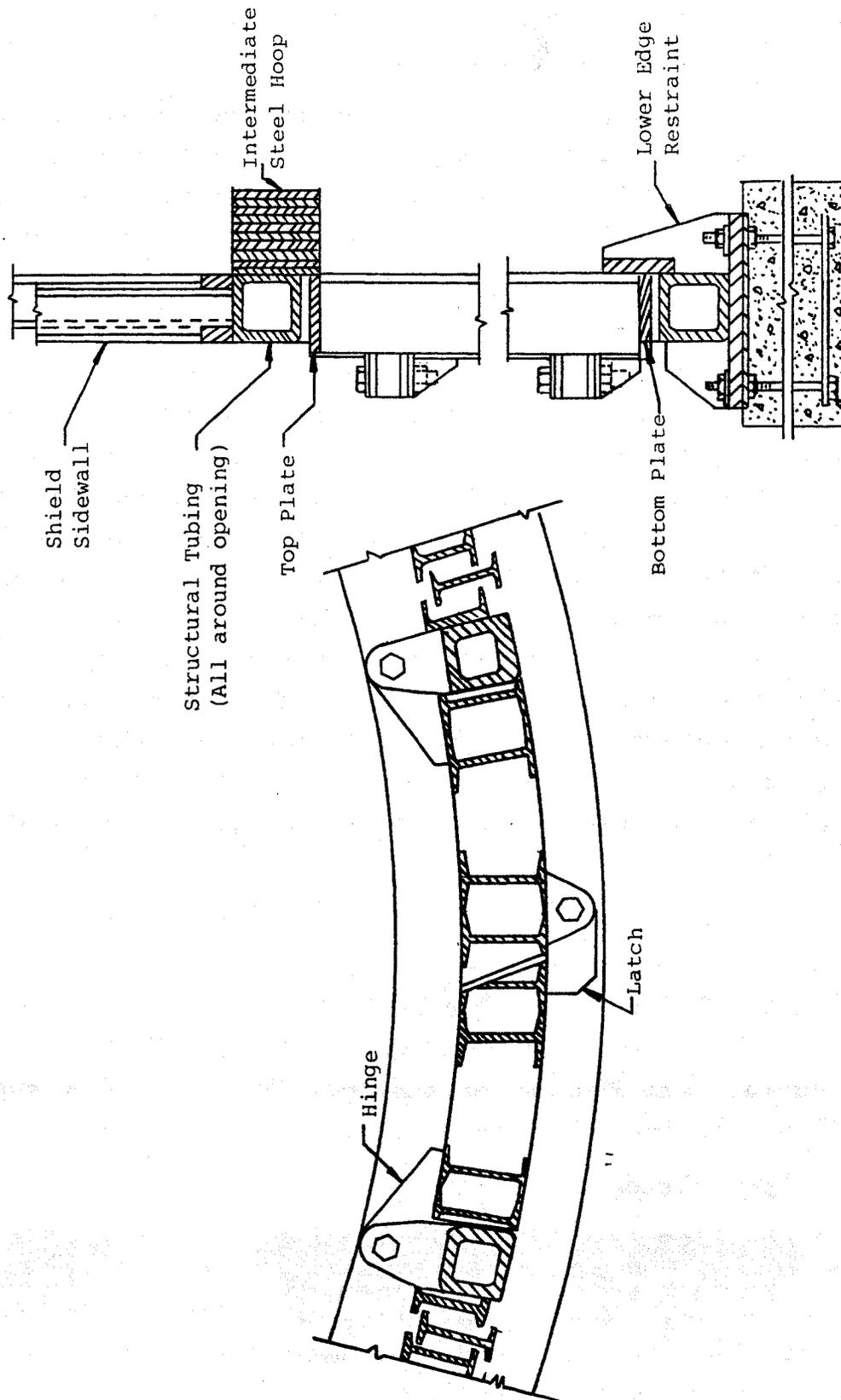


Figure A-3. Door - Group 3 Shield

square steel tubing anchored to the shield foundation. A latch between the two leaves maintains the door in the closed position.

Gaps between exposed flanges inside the shield are covered with closure strips. The strips are 1-1/2 inches wide by 1/4 inch thick and have 1/4-inch diameter holes along their centerlines for plug welding to the outer layers of the staggered beams. Edges of the closure strips are tack welded to the beam flanges onto which they overlap.

Dust from a manufacturing process could cause accumulation of explosive materials in hazardous amounts. To prevent explosive dust from accumulating in the interior of the structure walls or escaping outside the shield, two liners of 1/2 x 2-inch x 22 gauge corrugated steel plate are placed on the inside surface of the shield. Two liners were chosen based on results of the proof-test series. One liner was adequate for the shielding function but was severely distorted by the detonation. Subsequently, the two-liner concept was tested with good results and adopted for future use. A frangible liner of Velostat plastic is applied to the exterior surface of the shield to prevent the entry and accumulation of explosive dust within the shield wall.

The Group 3 shield foundation and roof are circular monolithic reinforced concrete slabs; details of the slab designs are shown in Fig. A-2. The slabs are 13 feet 4 inches in diameter, 18 inches thick and designed in accordance with TM5-1300 procedures. The foundation and roof exhibited only superficial cracking during proof tests of the Group 3 shield.

A.2.2 Application

The Group 3 shield design has been tested and safety approved for 36.6 pounds of 50/50 pentolite (41.32 lb TNT equivalent). Typical applications of this design are (a) 5.56-mm blank cartridge loading and (b) 20/30-mm HEI (High Explosive Incendiary) projectile fill and press operations.

Based on the test results, external pressure will be reduced to 2.3 psi at a distance of 6.2 feet from the exterior of the shield. The fireball is restricted to within four feet of the shield wall.

The Group 3 suppressive shield design can be utilized for operations that

- Require a maximum 100 square feet of floor area with a 10-foot maximum clear height.
- Involve bare charge weights equivalent to 36.6 pounds of 50/50 pentolite (41.32 lb TNT equiv.; maximum W/V ratio = 0.04157 lb/ft³; minimum Z = 1.627 ft/lb^{1/3} to side-wall and minimum Z = 1.446 ft/lb^{1/3} for roof).
- Produce no fragments that cannot be defeated by one inch of mild steel.
- Are compatible with a fireball at four feet and external pressure of 2.3 psi at 6.2 feet from the exterior of the shield.

A.2.3 Modification

The height of the shield may be increased or decreased modularly by adding or removing bands and using longer or shorter beam lengths. However, the free span cannot be changed, the ratio of W/V may not be increased, and Z cannot be decreased. The shield size may be scaled down provided the stress levels calculated using the analysis methods provided in Chapter 5 are equal to or lower than those in the safety approved shield design.

In addition to the structural adequacy of a proposed Group 3 shield modification, the fragment threat for any application must be such that the threat is defeated by one inch of mild steel.

A.3 SHIELD GROUP 4

A.3.1 Description

The Group 4 suppressive shield shown in Fig. A-4 employs a modular configuration consisting of a steel frame with panels made up of nested angles and perforated plates. The nominal outside dimensions are 11.5 feet wide by 16.4 feet long by 10.4 feet high; the inside dimensions are 9.2 feet wide by 13.1 feet long by 9.3 feet high.

Construction details for the Group 4 suppressive shield are shown in Fig. A-5. The structural framing members are W14 x 61 wide flange steel sections. A schematic of the structural frame is shown in Fig. A-6. The lower ends of the vertical members are attached to a 3/4-inch base plate which covers the entire floor of the shield.

The panels spanning between the framing members have the cross section shown in Fig. A-4. There are four layers of 3/16-inch perforated steel plate. One plate is on the innermost face of the panels, and three are spaced slightly apart near the panel centerline. The two layers of interlaced structural steel angles provide stiffness to the panel and resistance against fragment penetration. The panels are installed in the frame and wedged into place as shown in Fig. A-6b.

The Group 4 shield will typically utilize a slab on grade foundation such as shown in Fig. A-5f. High speed motion pictures of the Group 4 proof tests showed an upward movement of the structure of from 1 to 2 inches because the structure was not rigidly attached to its foundation. This movement could cause problems in an operating environment if utility penetrations are not appropriately designed. Foundation tiedown procedures used in the Group 5 or 81-mm shield may be applied to this shield if rigid tiedown is required.

Access to the Group 4 shield is provided by a sliding door. The cross section of the door is identical to the sidewall

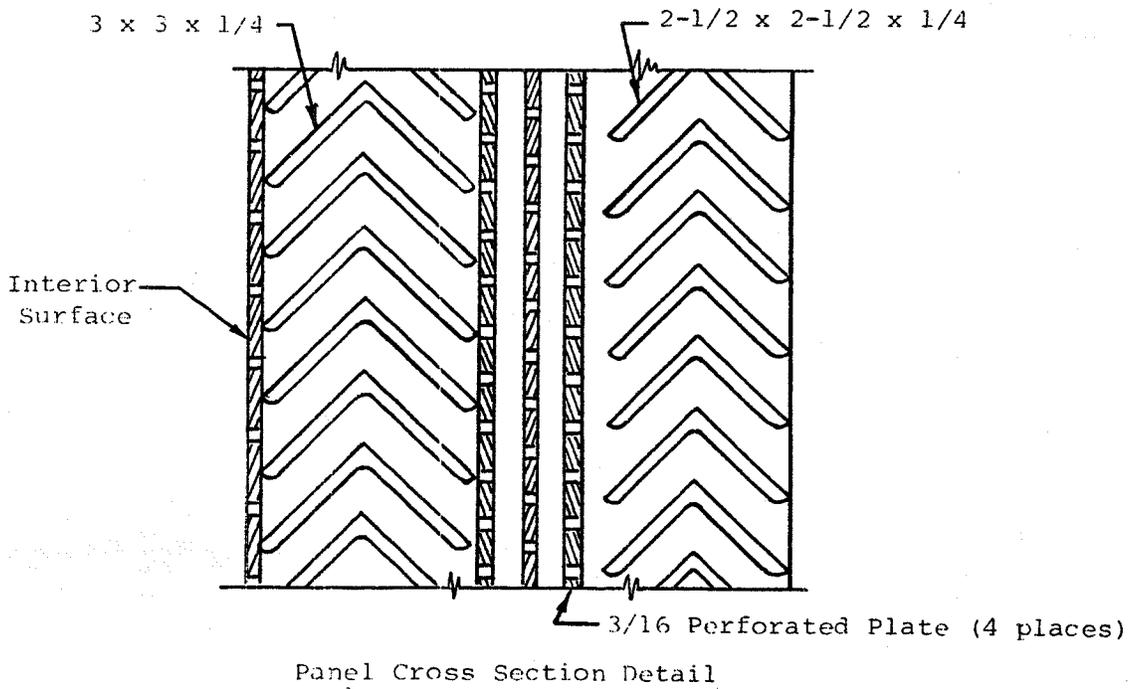
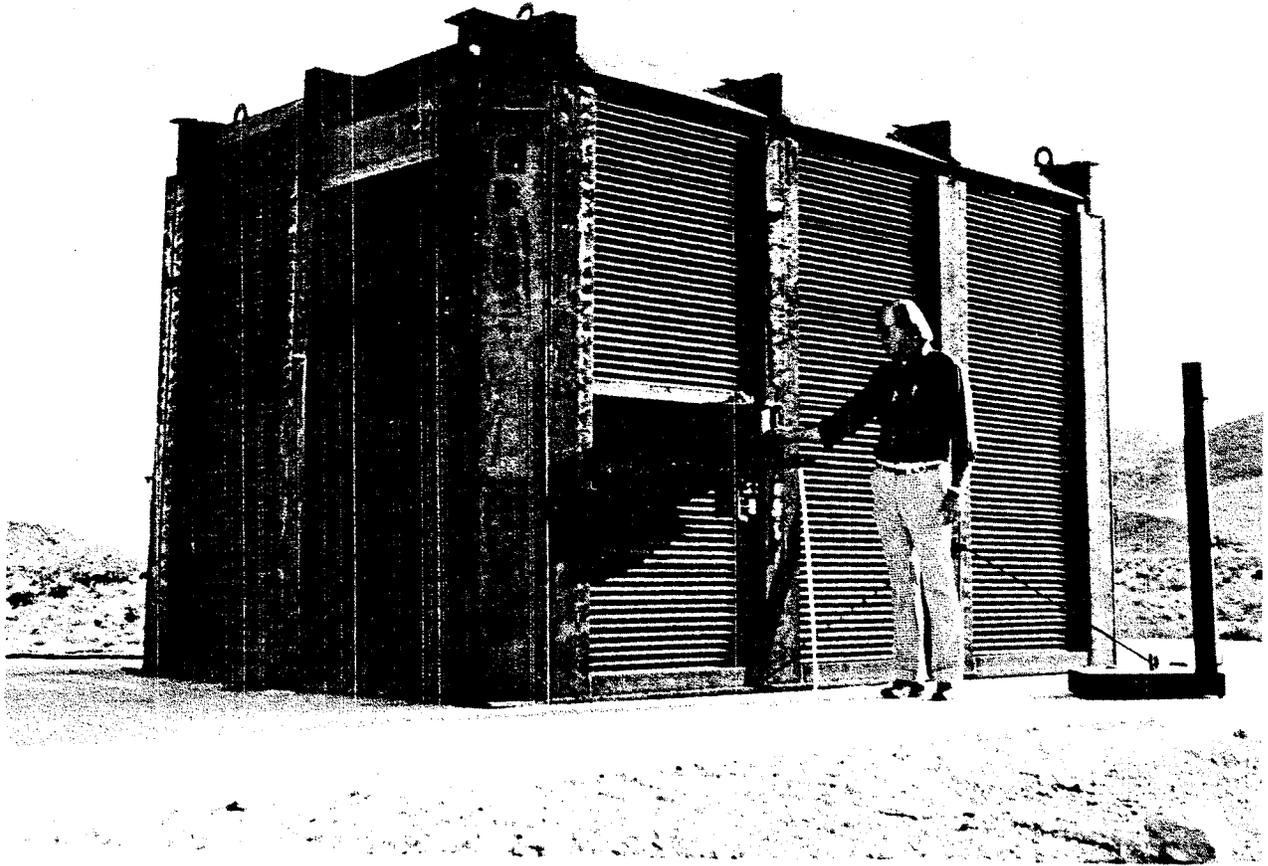
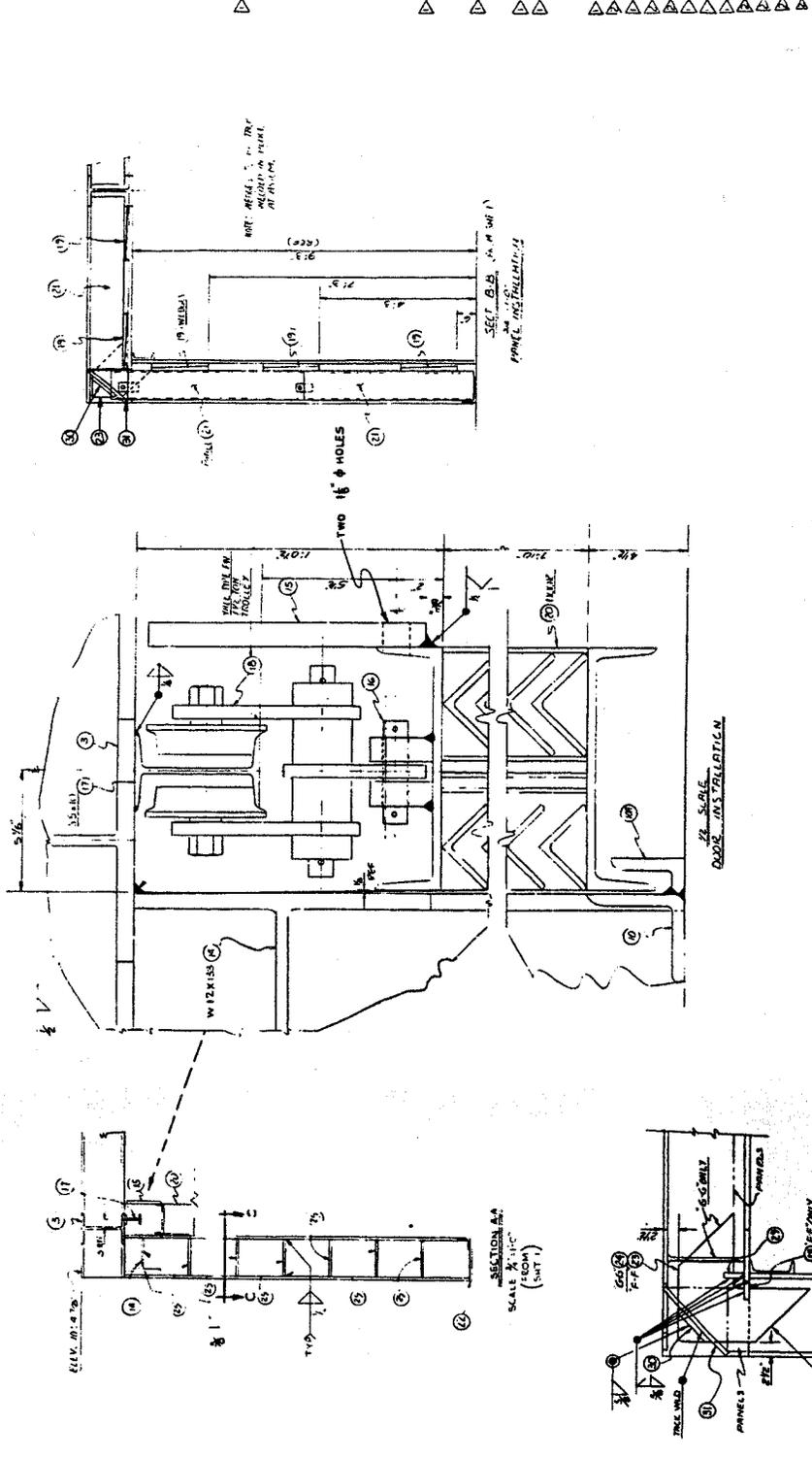
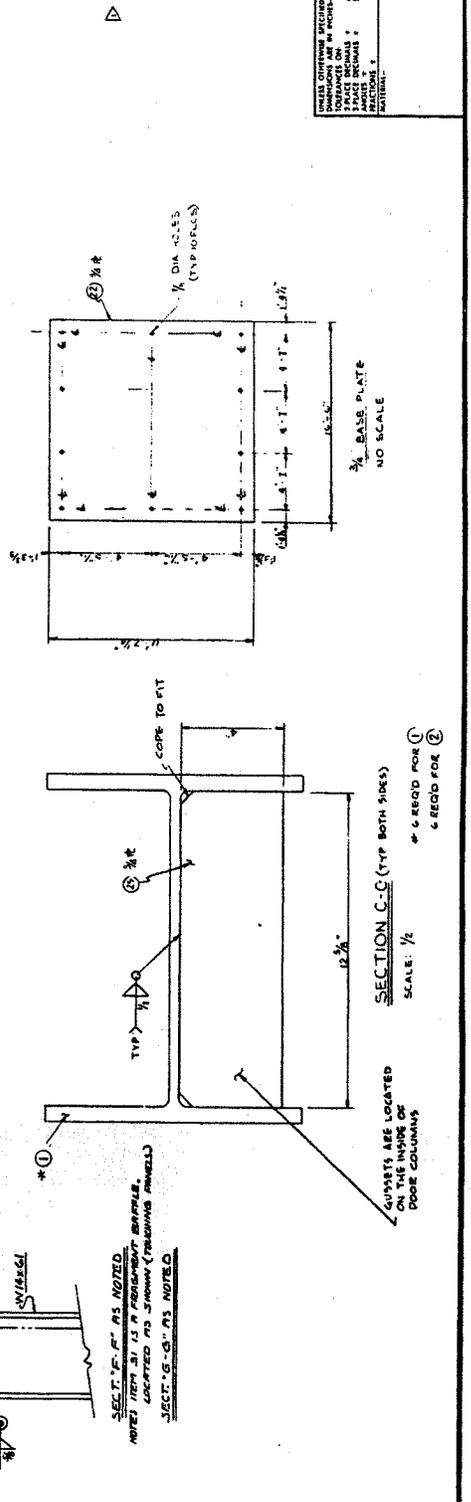


Figure A-4. Group 4 Suppressive Shield

NO.	DESCRIPTION	QUANTITY	UNIT	REMARKS
10	W 14 X 11 X 7/16	1	LB	W/14 X 11 X 7/16
11	W 12 X 10 X 7/16	1	LB	W/12 X 10 X 7/16
12	W 10 X 8 X 7/16	1	LB	W/10 X 8 X 7/16
13	W 8 X 6 X 7/16	1	LB	W/8 X 6 X 7/16
14	W 6 X 4 X 7/16	1	LB	W/6 X 4 X 7/16
15	W 4 X 3 X 7/16	1	LB	W/4 X 3 X 7/16
16	W 3 X 2 X 7/16	1	LB	W/3 X 2 X 7/16
17	W 2 X 1 X 7/16	1	LB	W/2 X 1 X 7/16
18	W 1 X 1/2 X 7/16	1	LB	W/1 X 1/2 X 7/16
19	W 1/2 X 1/4 X 7/16	1	LB	W/1/2 X 1/4 X 7/16
20	W 1/4 X 1/8 X 7/16	1	LB	W/1/4 X 1/8 X 7/16
21	W 1/8 X 1/4 X 7/16	1	LB	W/1/8 X 1/4 X 7/16
22	W 1/4 X 1/2 X 7/16	1	LB	W/1/4 X 1/2 X 7/16
23	W 1/2 X 3/4 X 7/16	1	LB	W/1/2 X 3/4 X 7/16
24	W 3/4 X 1 X 7/16	1	LB	W/3/4 X 1 X 7/16
25	W 1 X 1 X 7/16	1	LB	W/1 X 1 X 7/16
26	W 1 X 1 X 7/16	1	LB	W/1 X 1 X 7/16
27	W 1 X 1 X 7/16	1	LB	W/1 X 1 X 7/16
28	W 1 X 1 X 7/16	1	LB	W/1 X 1 X 7/16
29	W 1 X 1 X 7/16	1	LB	W/1 X 1 X 7/16
30	W 1 X 1 X 7/16	1	LB	W/1 X 1 X 7/16
31	W 1 X 1 X 7/16	1	LB	W/1 X 1 X 7/16



NO.	DESCRIPTION	QUANTITY	UNIT	REMARKS
10	W 14 X 11 X 7/16	1	LB	W/14 X 11 X 7/16
11	W 12 X 10 X 7/16	1	LB	W/12 X 10 X 7/16
12	W 10 X 8 X 7/16	1	LB	W/10 X 8 X 7/16
13	W 8 X 6 X 7/16	1	LB	W/8 X 6 X 7/16
14	W 6 X 4 X 7/16	1	LB	W/6 X 4 X 7/16
15	W 4 X 3 X 7/16	1	LB	W/4 X 3 X 7/16
16	W 3 X 2 X 7/16	1	LB	W/3 X 2 X 7/16
17	W 2 X 1 X 7/16	1	LB	W/2 X 1 X 7/16
18	W 1 X 1/2 X 7/16	1	LB	W/1 X 1/2 X 7/16
19	W 1/2 X 1/4 X 7/16	1	LB	W/1/2 X 1/4 X 7/16
20	W 1/4 X 1/8 X 7/16	1	LB	W/1/4 X 1/8 X 7/16
21	W 1/8 X 1/4 X 7/16	1	LB	W/1/8 X 1/4 X 7/16
22	W 1/4 X 1/2 X 7/16	1	LB	W/1/4 X 1/2 X 7/16
23	W 1/2 X 3/4 X 7/16	1	LB	W/1/2 X 3/4 X 7/16
24	W 3/4 X 1 X 7/16	1	LB	W/3/4 X 1 X 7/16
25	W 1 X 1 X 7/16	1	LB	W/1 X 1 X 7/16
26	W 1 X 1 X 7/16	1	LB	W/1 X 1 X 7/16
27	W 1 X 1 X 7/16	1	LB	W/1 X 1 X 7/16
28	W 1 X 1 X 7/16	1	LB	W/1 X 1 X 7/16
29	W 1 X 1 X 7/16	1	LB	W/1 X 1 X 7/16
30	W 1 X 1 X 7/16	1	LB	W/1 X 1 X 7/16
31	W 1 X 1 X 7/16	1	LB	W/1 X 1 X 7/16



THIS SYMBOL INDICATES A DIMENSIONAL QUANTITY OR ADDITION CHANGE HAS BEEN MADE TO THAT PART.

SEE DET. 1 OF 2 FOR EXPLANATION OF THE 100 SYMBOL IN DET. 2

DATE: 1/25/54

BY: [Signature]

SCALE: 1/2" = 1'-0"

NO. OF SHEETS: 3

SHEET NO.: 3

Figure A-5b. Group 4 Shield Construction Details (continued)

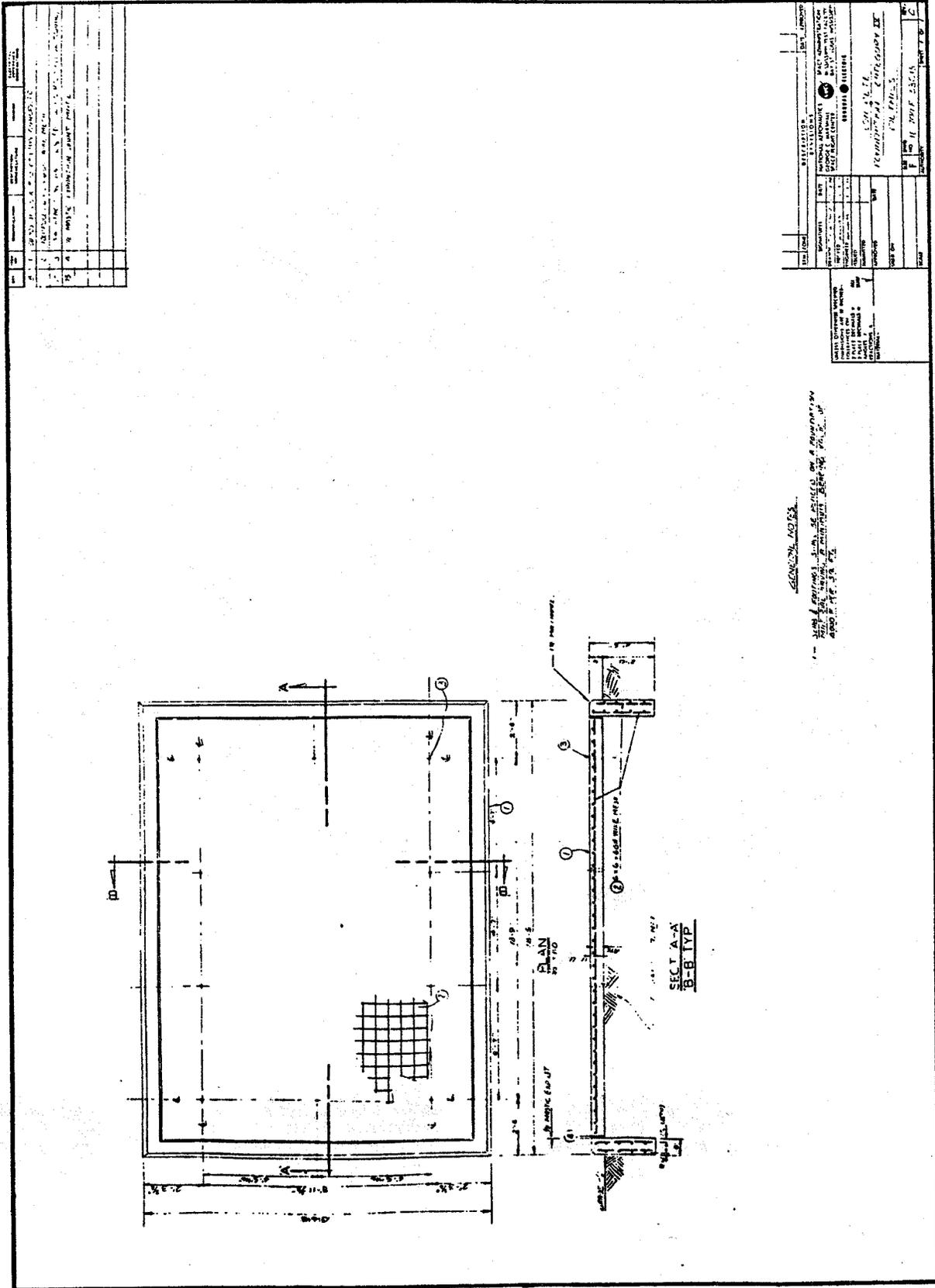


Figure A-5f. Group 4 Shield Construction Details (concluded)

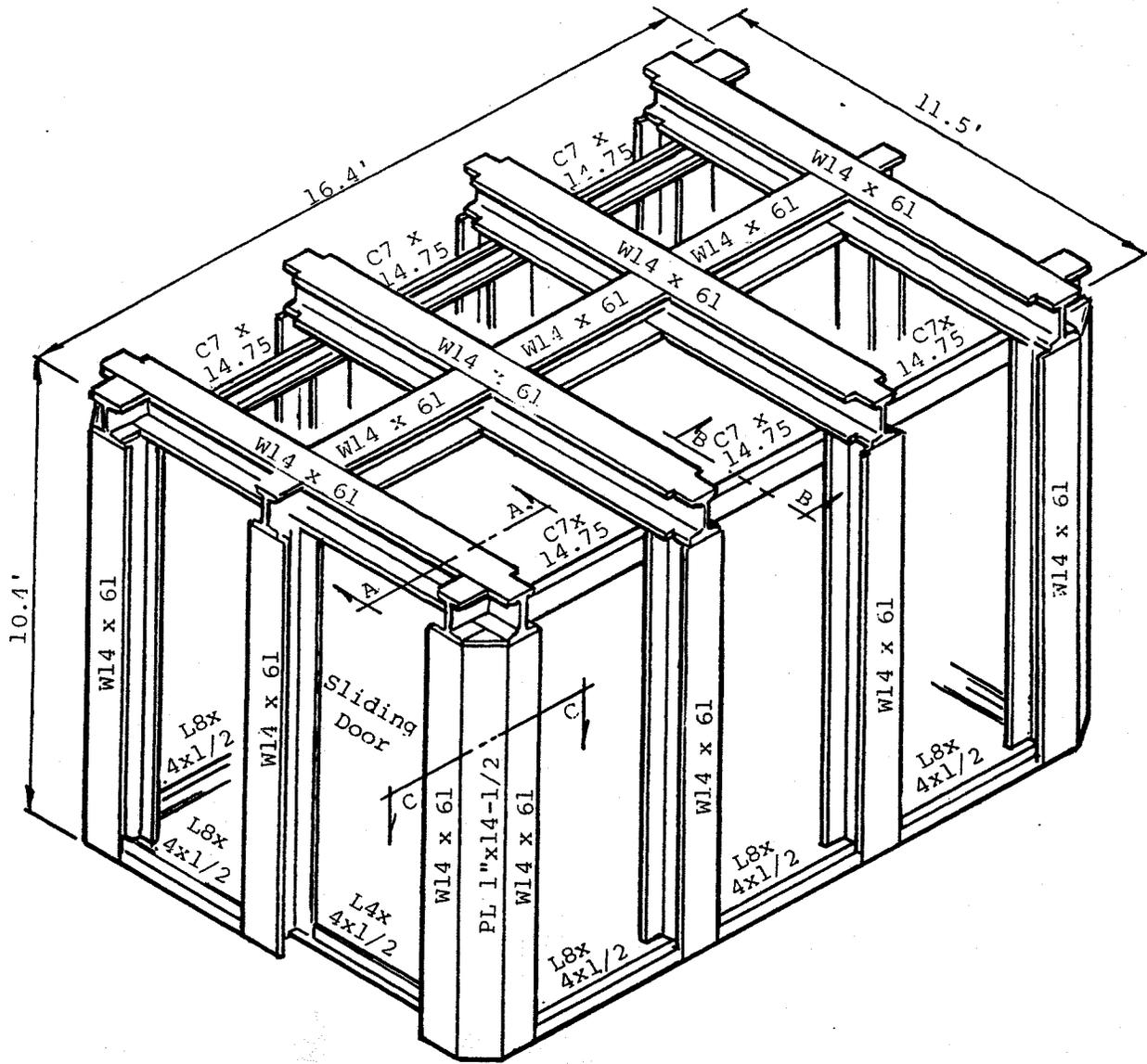
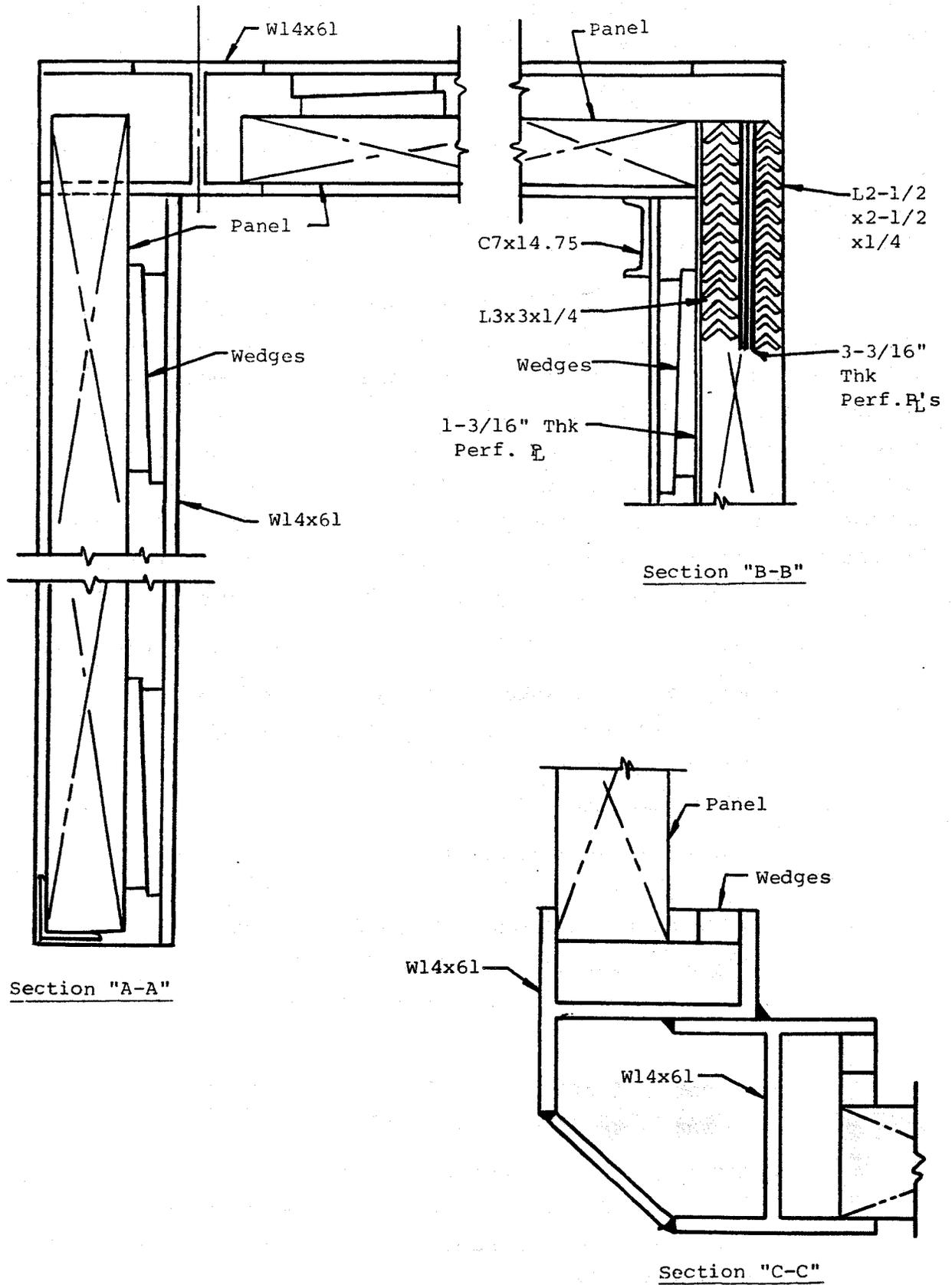


Figure A-6a. Schematic of Group 4 Shield Frame



Figures A-6b. Schematic of Group 4 Shield Frame (concluded)

panels. A view of the door cross section and its monorail support system may be seen in Fig. A-5b.

A.3.2 Application

This design is applicable to munition operations involving up to nine pounds of bare charge of 50/50 pentolite, or equivalent. A typical application would be a 105-mm high explosive projectile fuze-insert-and-torque operation.

The Group 4 shield has been tested and safety approved for a 9-pound bare charge of 50/50 pentolite (10.16 lb TNT equivalent) and fragments from the simultaneous detonation of two 105-mm projectiles located on simulated fuze-insert-and-torque equipment. The shield contains all fragments resulting from the specified detonation (minimum steel thickness along any fragment path is 1.46 inches), restricts the fireball to within 10 feet of the shield, and prevents external pressures greater than 2.3 psi at any point beyond 19 feet from the exterior walls.

Group 4 shields can be considered for operations that

- Require a maximum rectangular floor area 9.2 feet wide by 13.1 feet long with a maximum ceiling height of 9.3 feet (inside dimensions).
- Employ bare charge weights equivalent to nine pounds of 50/50 pentolite (10.16 lb TNT equiv; maximum W/V ratio = 0.00762 lb/ft³; minimum Z = 2.23 ft/lb^{1/3} to side-wall and minimum Z = 2.19 ft/lb^{1/3} for roof).
- Produce fragments incapable of perforating 1.46 inches of steel.
- Are compatible with a fireball 10 feet from the shield and external pressure of 2.3 psi up to 19 feet from the shield exterior walls.

A.3.3 Modification

The length of this particular shield design could be increased with modular extensions almost indefinitely for its rated charge weight. This is due to the way the airblast loading is resisted by the structural system. Each module (wall and roof panels and frames) is capable of carrying its rated loading independent of the adjacent modules since this loading is carried primarily by one-way flexural action in the direction of the short panel dimension. Shield length can be decreased modularly by reducing the number of panels in the sidewall, provided W/V is not increased and scaled distances Z are not decreased.

Changing the span or the height of the Group 4 shield design for the rated charge weight would be subject to the same restrictions discussed above for the Group 3 design. The fragment threat for any proposed application must be such that the threat is defeated by 1.46 inches of mild steel.

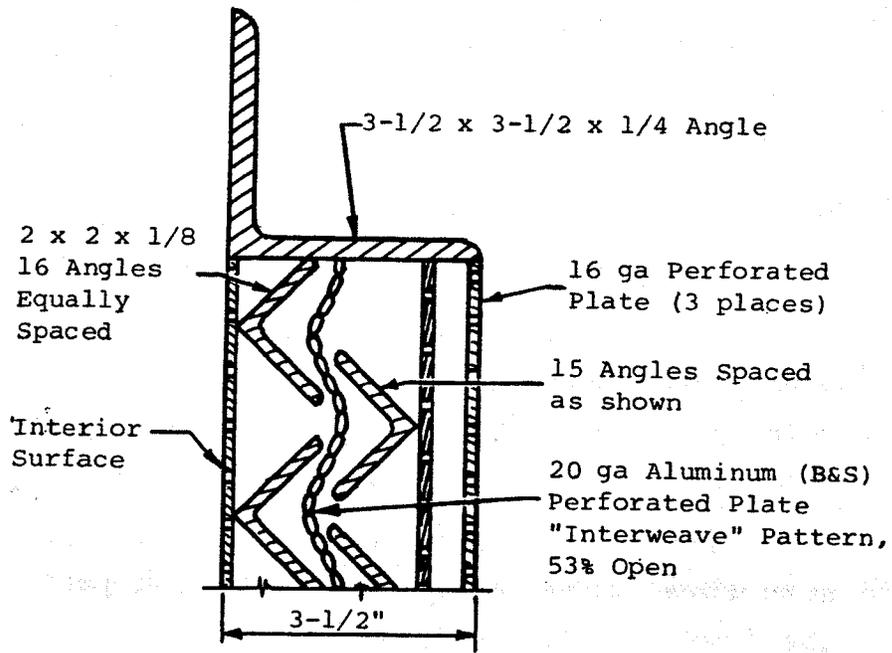
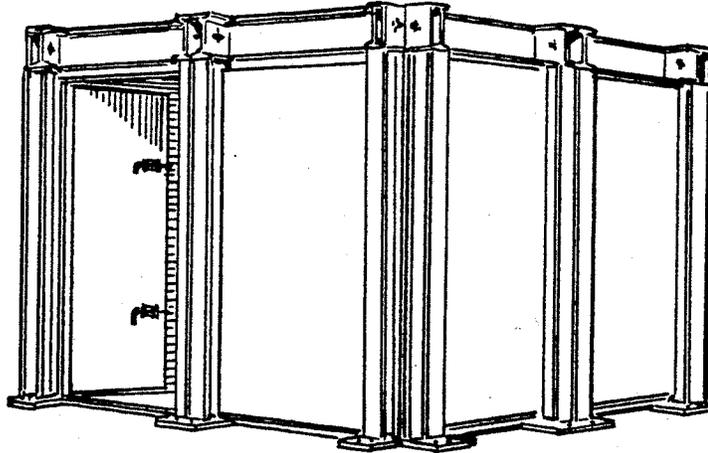
A.4 SHIELD GROUP 5

A.4.1 Description

The Group 5 design shown in Fig. A-7 employs a steel frame with panels made up of perforated plate, angles and screen. The outside dimensions are 12.6 feet square by 9.2 feet high, and the inside dimensions are 10.4 feet square by 8.5 feet high.

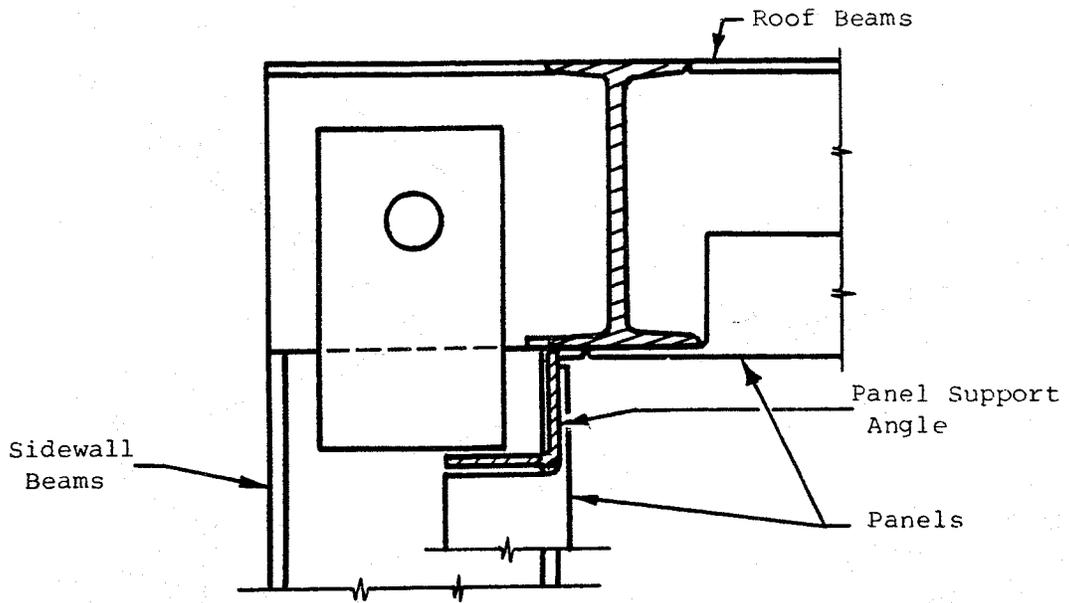
The Group 5 shield wall and roof panels include the basic structural frame members as integral parts of the panel, i.e., the frame columns and roof beams are part of the panels. The shield is assembled by bolting or welding the various panels together. Pertinent connection details are illustrated in Figs. A-8 through A-10; the Group 5 shield fabrication drawings are shown in Fig. A-11.

A typical Group 5 panel cross section is shown in Fig. A-7. Each panel contains three layers of 16 gauge perforated steel plates. One plate is on the inner panel surface and

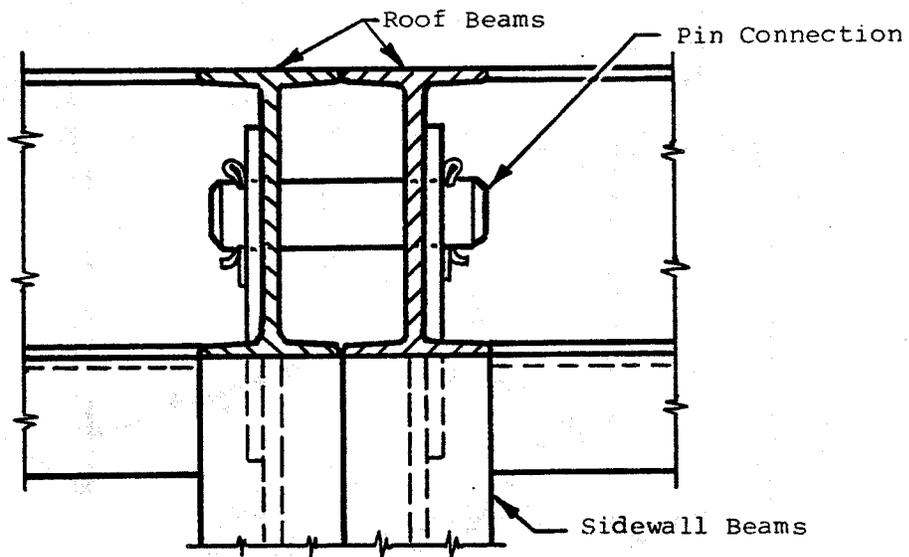


Panel Cross Section Detail

Figure A-7. Group 5 Suppressive Shield



a. Side View



b. End View

Figure A-8. Center Framework Connection - Group 5 Shield

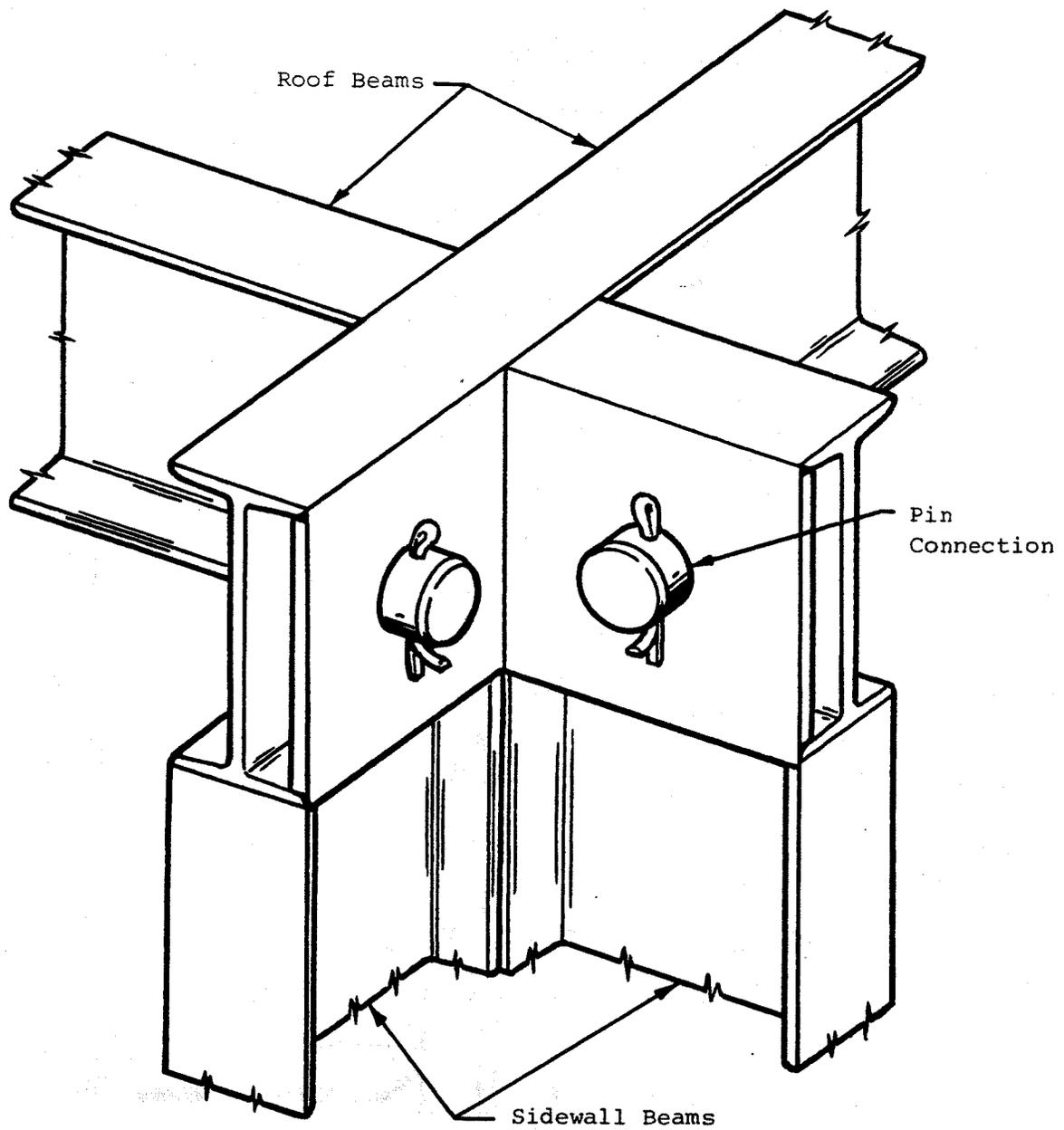


Figure A-9. Edge Framework - Group 5 Shield

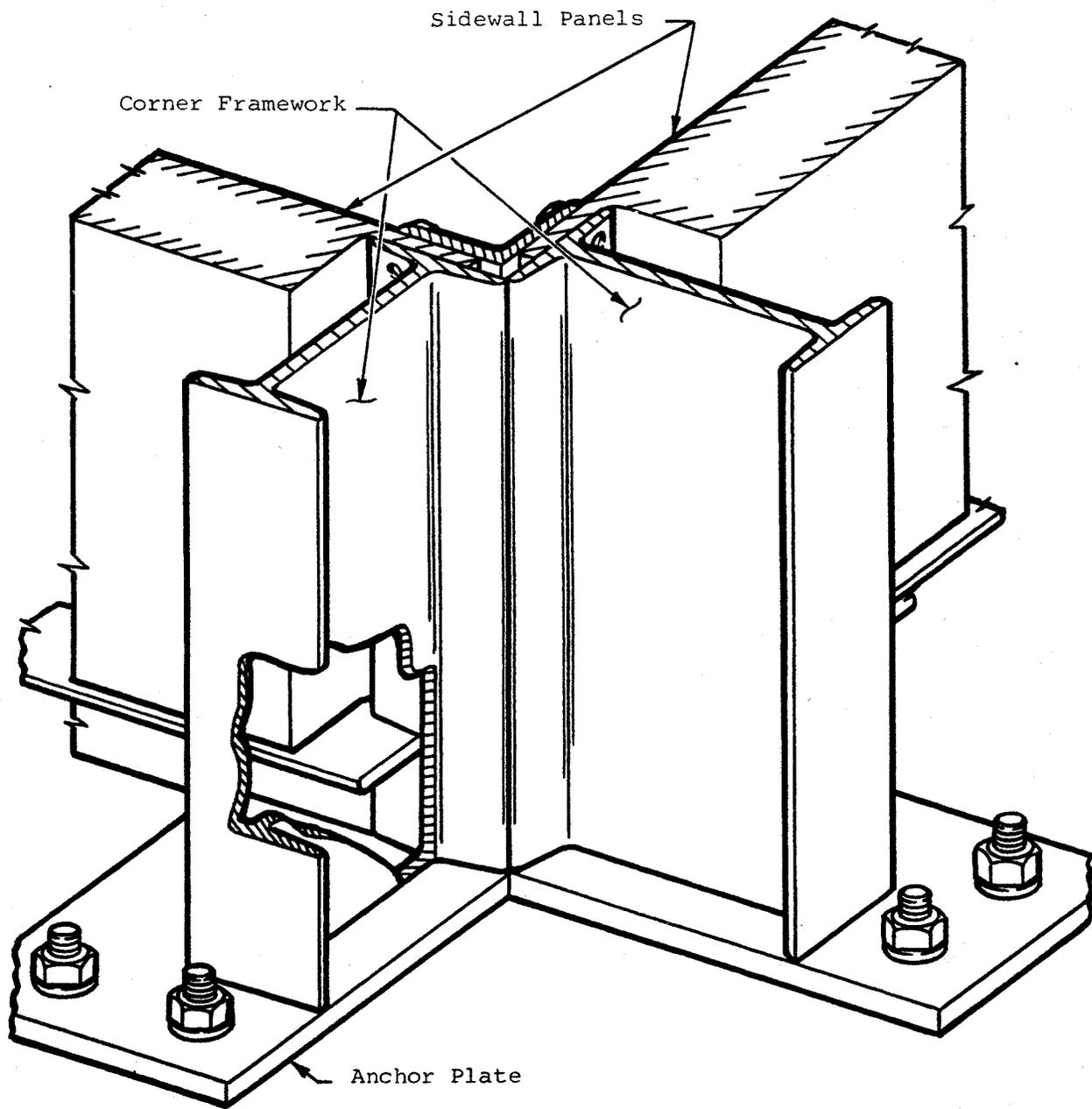
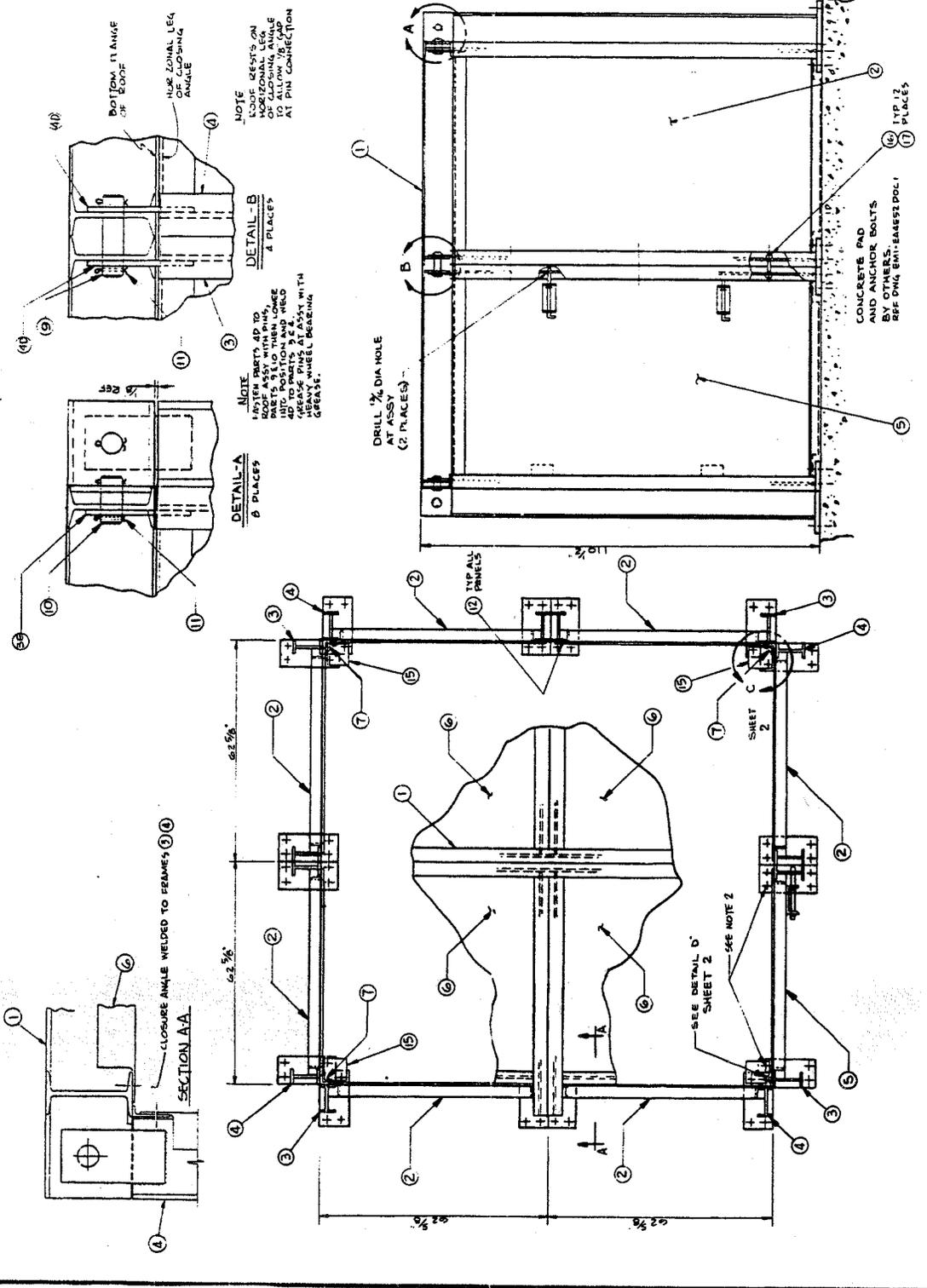


Figure A-10. Corner Anchor Plate - Group 5 Shield

NO.	DESCRIPTION	QTY	UNIT	REMARKS
1	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
2	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
3	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
4	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
5	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
6	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
7	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
8	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
9	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
10	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
11	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
12	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
13	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
14	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
15	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
16	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
17	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
18	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
19	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
20	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
21	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
22	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
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24	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
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26	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
27	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
28	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
29	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
30	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
31	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
32	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
33	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
34	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
35	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
36	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
37	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
38	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
39	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
40	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
41	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
42	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
43	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
44	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
45	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
46	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
47	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
48	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
49	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			
50	1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8"			

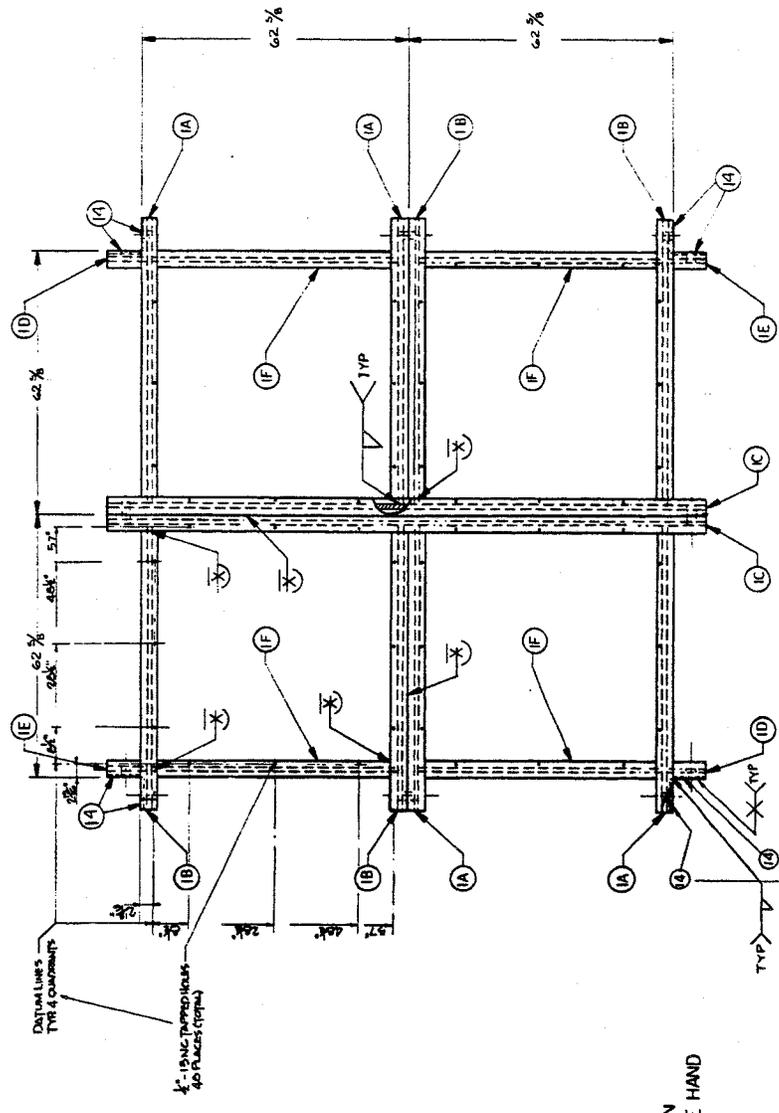
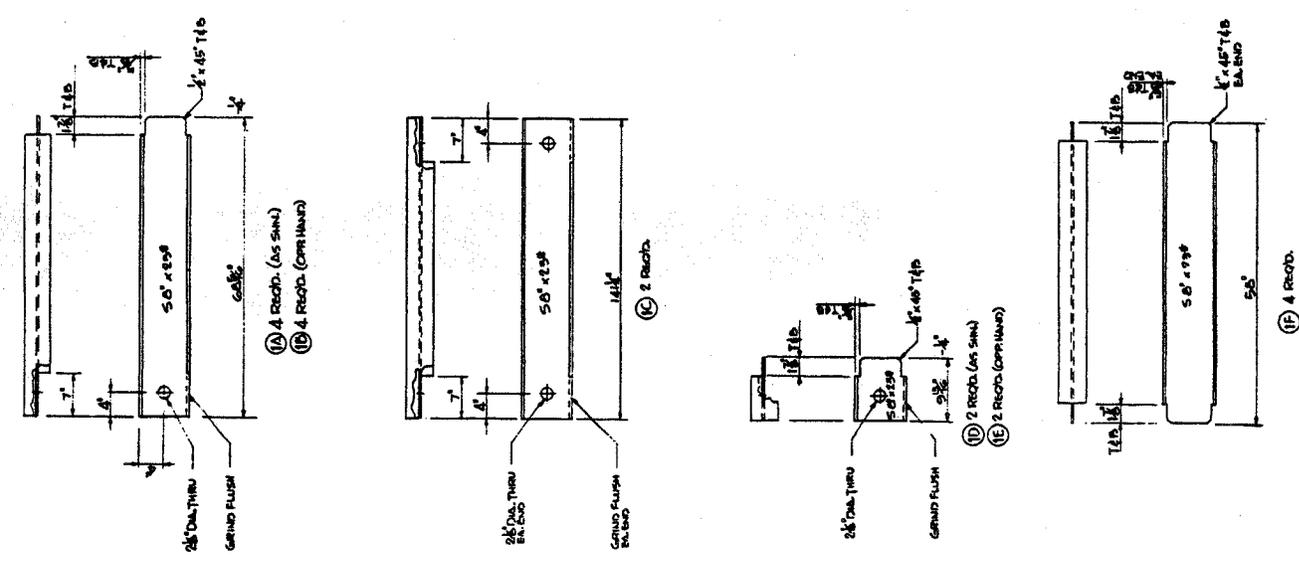
- Notes:
- 1/2" TAPPED HOLES IN FRAMES (SHTS 3 & 5) 4 3/8" TO ALLOW FOR EASY REMOVAL OF DOOR FRAME TO ALLOW FOR DOOR SWING.
 - CUT OFF EXCESS ANCHOR BOLT ABOVE AND AFTER ALLOW FOR DOOR SWING.
 - HINGES SHOULD BE PROTECTED IF THIS STRUCTURE MUST WITHSTAND REPEATED FRAGMENTATION TESTS.
 - DOOR OPERATING SLUING; DOOR DESIGN SEE DWG NO. 10-700F-2500.

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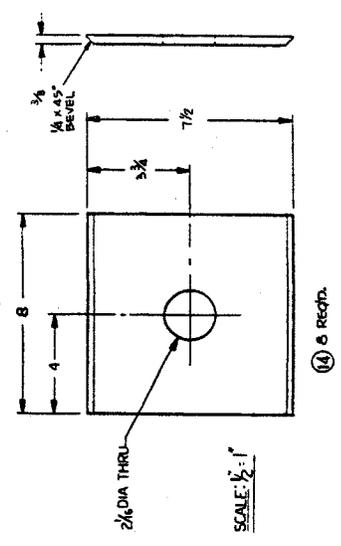


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Figure A-11a. Group 5 Shield Construction Details



(D) 2 AS SHOWN
 (E) 2 OPPOSITE HAND



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1	10/1/77	ISSUED FOR PERMIT	J. J. [unclear]	[unclear]
2	10/1/77	REVISIONS	[unclear]	[unclear]
3	10/1/77	REVISIONS	[unclear]	[unclear]
4	10/1/77	REVISIONS	[unclear]	[unclear]
5	10/1/77	REVISIONS	[unclear]	[unclear]
6	10/1/77	REVISIONS	[unclear]	[unclear]
7	10/1/77	REVISIONS	[unclear]	[unclear]
8	10/1/77	REVISIONS	[unclear]	[unclear]
9	10/1/77	REVISIONS	[unclear]	[unclear]
10	10/1/77	REVISIONS	[unclear]	[unclear]

DIVISION: CIVIL ENGINEERING
 PROJECT: SPACE ADMINISTRATION
 GEORGE L. MARSHALL SPACE FLIGHT CENTER
 BAY ST. LOUIS, MISSISSIPPI
 GENERAL: WELDED ROOF
 SPECIFIC: AN-SF MEELY IMPRESSIVE STRUCTURE
 DRAWING NO. 100 IE 700F 33011
 SHEET 3 OF 7

Figure A-11c. Group 5 Shield Construction Details (continued)

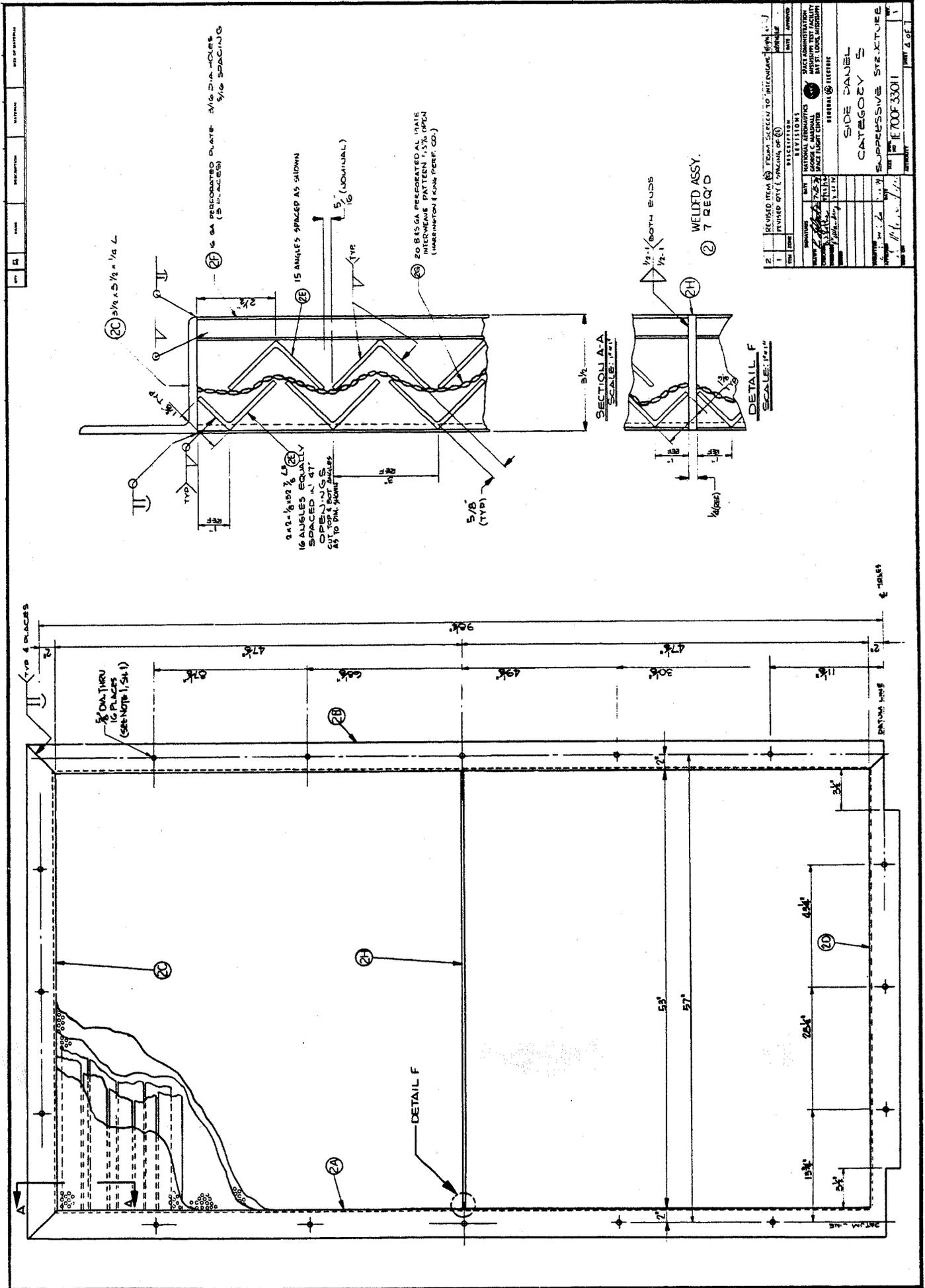


Figure A-11d. Group 5 Shield Construction Details (continued)

